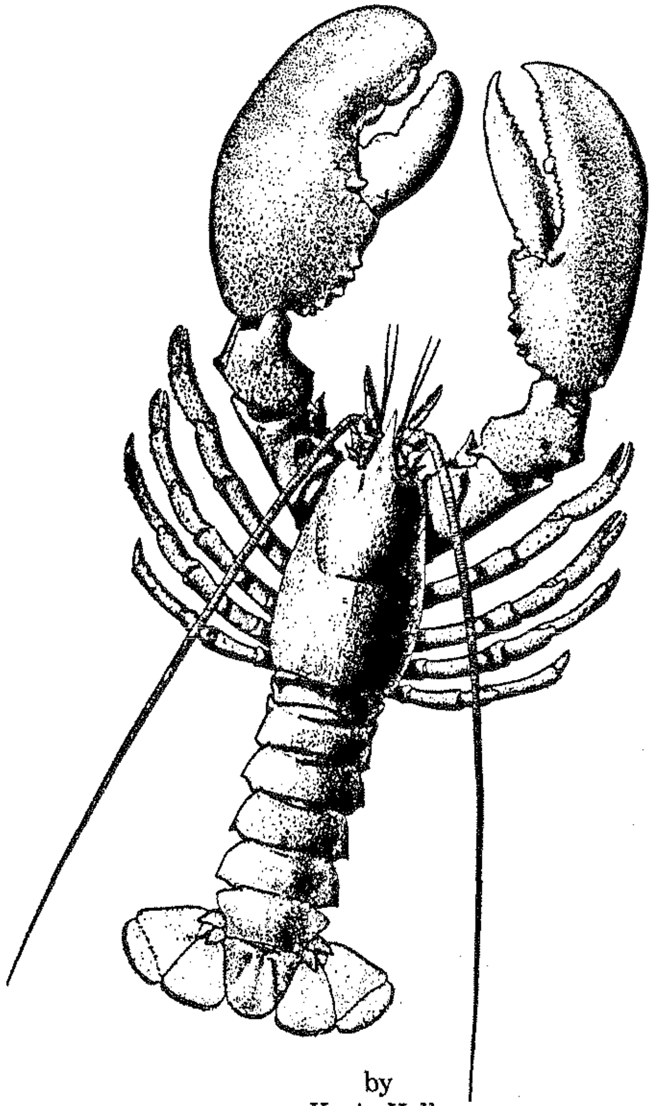
Temperature-Molt Relationships in Lobsters near Boothbay Harbor, Maine 1989 – 92



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Introduction

Since 1989 the Lobster and Crab Fisheries Division of the Maine Department of Marine Resources (DMR) has monitored nearshore sea bottom temperature. One of the primary reasons for this is to examine the effect of temperature on molting patterns of American lobsters (Homarus americanus) in the nearshore zone. Historically for coastal Maine only a limited amount of bottom temperature data which could be related to lobsters inhabiting nearshore areas have been collected. Although continuous sea surface temperature records from the Boothbay Harbor area are available from 1905 to the present, nearshore bottom temperature information for coastal Maine consists almost entirely of data collected during various research cruises at different locations throughout the Gulf of Maine at depths of 10-920 ft. (Colton and Stoddard 1973; DMR, unpublished data; Townsend 1985; Townsend and Christensen 1986; Townsend et al. 1987) and is rather sporadic. There have been no data reported from fixed locations with continuous monitoring.

Molting, also referred to as "shedding" or ecdysis, is the process by which the lobster casts off its old shell and acquires a new one, and is how lobsters increase in size. Each year during shedding season many lobsters below minimum legal size become "recruited" into the legal size range for commercial harvest along the Maine coast. The Maine fishery is, in fact, dependent on these newly-molted recruits for approximately 80-90% of the annual catch.

Temperature is known to influence many biological aspects of the American lobster, including growth rate, molting, size at sexual maturity, egg development and larval survival. Temperature also affects more behavioral lobster life history aspects such as distribution and catchability. Molt timing as well as molt frequency is known to be influenced by temperature. For example, pre-recruit and legal-sized lobsters from warmer waters such as western Long Island Sound and the southern Gulf of St. Lawrence molt earlier in the season and more frequently (some areas having both a spring and a fall molt) than similar-sized lobsters from colder areas such as the Bay of Fundy and southern Nova Scotia (Aiken and Waddy 1986).

Thus lobsters from warmer areas have a more rapid growth rate than their colder water counterparts, at least until sexual maturity, after which growth rate declines. As a result of a faster growth rate lobsters inhabiting warmer areas achieve sexual maturity sooner but generally have a smaller mean size. Adult lobsters from Maine waters normally molt only once per year (sexually mature females generally molt once every two years in synchrony with the reproductive cycle).

The minimum temperature level required for lobster growth is 41-43°F (Aiken 1980). Lobsters are inhibited from molting at temperatures below this range. Most inshore lobsters in northern waters overwinter in a **passive** premolt phase. In deeper offshore waters, however, lobsters are able to continue molting over a much greater part of the year due to warmer winter temperatures

(Aiken and Waddy 1986). The active premolt phase, which irreversibly leads to ecdysis, begins as temperatures surpass 41-43°F. The time to shedding (under laboratory conditions) once this active premolt is initiated is 36-40 days at 50°F and 26-28 days at 59°F (Aiken 1973). Therefore bottom temperatures in spring and early summer may be a major factor in determining when inshore shedding commences. The effect of temperature on lobster molting for an area near the Boothbay region of mid-coast Maine will be considered here.

Study Location and Methods

Two sites near Boothbay Harbor were selected for placement of computer-activated temperature recorders on bottom beginning in May 1989 (Figure 1). The general characteristics desired for the sites were proper depth, hard bottom substrate, ease of location from the surface using land bearings and ease of location on the bottom by divers. The shallower site (Spruce Point) selected was at 45 ft. depth and the deeper site (Ram Island) was at 90 ft. depth.

A pyramid-shaped concrete mooring block was constructed to house each recorder. Each block weighed approximately 200 lbs. The pyramid shape was intended to avoid entanglement with any lines or trawls which may come in contact with the block. A thermograph was placed inside a PVC tube set into the block. Temperature was recorded every two hours at each site and daily temperature means were then calculated. The probes were retrieved and replaced twice per year. Data were downloaded from the thermographs to a portable computer for storage and later analysis.

Molting patterns were determined by frequency of new-shell, or "shedder", lobsters caught in DMR research traps during 1989-92. For purposes of this study, when at least 75% of legal-size (3 1/4 - 5 in. carapace length (CL)) lobsters in three consecutive daily catches were new-shell, peak molting was considered to have begun. Approximately 60 wire-mesh research lobster traps were fished by DMR personnel each year during July-November along the east side of Southport Island, approximately 1.3 naut. mi. from the Spruce Point and 2.3 naut. mi. from the Ram Island temperature sites (Figure 1). Traps were fished at depths of approximately 30-70 ft., depending on bottom contour and time of year. All gear was hauled, re-baited and re-set three times per week, weather permitting.

The major purpose of the trap research during these years was to experiment with gear selectivity factors such as escape vent size and location, and single vs. double parlor configurations. However since shell hardness (as described by Ennis (1977)) and CL were recorded for all lobsters, a very useful base of information for examining yearly molt patterns was available. Since determination of shell condition can be described as somewhat subjective, it should be noted that while one person evaluated this parameter during 1989-90 and most of

1991, another individual took over this task beginning in late 1991.

Results and Discussion

In both 1990 and 1991 the consistent 41-43°F (minimum temperature for active premolt) or higher range was achieved by mid-May to mid-June at Ram Island (Figure 2). (Since Ram Island temperatures were less variable than Spruce Point, and since the depth at this site was presumably more representative of that at which lobsters are found for a longer portion of the year, Ram Island data were used for most of this analysis). Subsequently, daily catches of legal-size lobsters in research traps were consistently at least 75% new-shell by 20 July in 1990 and 26 July in 1991 (Figure 3). Although winter (January-March) 1991 temperatures exceeded those of winter 1990, late spring and summer (July-September) temperatures were very comparable in those two years (Table 1), as were molting patterns.

Despite fairly comparable temperatures between 1989 and 1992, however, molting was appreciably different in these two years. In both 1989 and 1992, late spring bottom temperatures were markedly less than in 1990 and 1991, with the 41-43°F range attained during late May to late June of 1989 and 1992 (Figure 2). Summer temperatures in these two years were on average 1-3°F lower than in 1990 and 1991 (Table 1). Subsequently in 1989 molting was only slightly later than 1991, while in 1992 molting was very delayed (Figure 3). In fact, research trap catches of legal-size lobsters in 1992 did not reach the consistent 75% new-shell level until 25 September. By comparison, shedder rates in 1989 were very similar to 1990 and 1991, with consistent 75% new-shells attained 28 July 1989. The time between attainment of 41-43°F and onset of molting was 52-54 days in 1989-91, whereas 109 days elapsed in 1992.

Results to date indicate that in both 1990 and 1991 summer (July-September) bottom temperatures were higher than in 1989 and 1992 at both sites. Molting patterns correlated well with temperature except for what occurred during the two cooler summers, 1989 and 1992. Although late spring bottom temperatures were comparable between 1989 and 1992, molting in 1992 was very delayed compared to the other years. (It should also be restated that there was a change in personnel determining shell hardness between 1991 and 1992 and this may have affected 1992's results.) Daily shedder frequencies were also much more variable in 1992 than in any other year (weekly averages eliminated some of this variability while indicating the more general trend) (Figure 3).

The delay in molting observed in our research traps in 1992 was reflected coastwide. During July 1992 only 47% of the commercial landings sampled coastwide by DMR personnel were new-shell lobsters. In comparison, shedders comprised 90% of the July catch in 1989, 82% in 1990 and 89% in 1991.

It was reported by Templeman (1936) that molting in the Maritime Provinces of Canada was delayed by at least one week for each approximately 2°F lower summer temperature between areas. Molting activity at a hatchery in Massachusetts peaked at temperatures of 59 to 68°F but seldom occurred below 50°F (Hughes and Matthiessen 1962). At our monitoring sites, however, temperatures did not reach the 59-68°F range. Over the four years since monitoring began, the highest temperature attained at Spruce Point was 57°F. At Ram Island the maximum temperature attained was 53°F. Highest average monthly temperatures at Ram Island for each year (except 1992, incomplete) were 50.1°F in September 1989, 52.0°F in October 1990 and 50.9°F in September 1991 (Table 1). Although warmer temperatures would be available to lobsters at shallower depths, peak molting in nearshore mid-coast Maine probably occurs at temperatures less than those observed at the Massachusetts hatchery.

Timing of annual molt has been found to be significantly correlated with May bottom water temperature in eastern Long Island Sound (NUSCO 1992). When May water temperatures in the eastern Sound were above average, molting peaked earlier and when May temperatures were below average molting peaked later. In our study area, May-June bottom temperature appears to have a large influence on onset of molting, although the delay in molting observed in 1992 was significantly longer than expected based on temperature. Perhaps, however, 1989 was the anomaly since although May-June temperature was about two weeks behind 1990 and 1991, and summer temperature continued quite low, molting appears not to have been appreciably affected. Additional bottom temperature information from these sites will have to be collected, and further years must be examined, before a more comprehensive understanding of the relation between temperature and biological aspects of lobsters in this region can be developed.

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Table 1. Mean monthly and yearly bottom temperature (°F) near Ram Island off Boothbay Harbor (approximately 90 ft. depth), 1989-92.

	Year			
	89	90	91	92
JAN	*	38.5	40.5	40.7
FEB	*	36.1	38.7	36.7
MAR	*	35.6	37.0	36.6
APR	*	36.8	38.8	37.1
MAY	**	40.8	41.1	39.1
JUN	43.1	44.1	44.1	42.8
JUL	44.7	45.9	45.8	45.0
AUG	47.1	49.5	50.0	47.1
SEP	50.1	51.7	50.9	48.9
OCT	49.2	52.0	50.3	**
NOV	47.9	48.7	48.6	*
DEC	40.8	45.8	43.7	*
YEAR	**	43.8	44.2	**

* data not available
** data incomplete

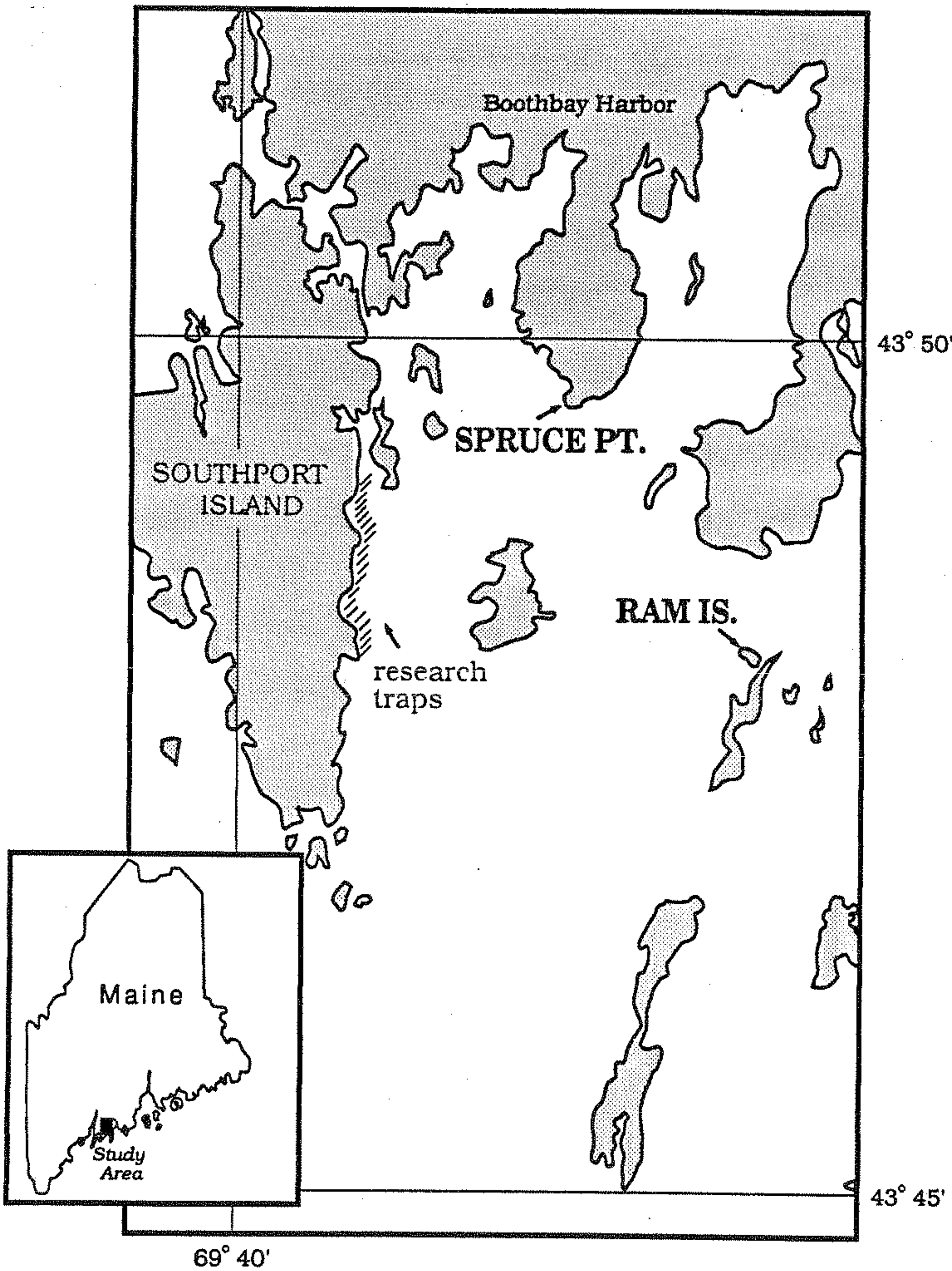

Figure 1. Chart of study area showing location of DMR research traps and bottom temperature monitoring sites.

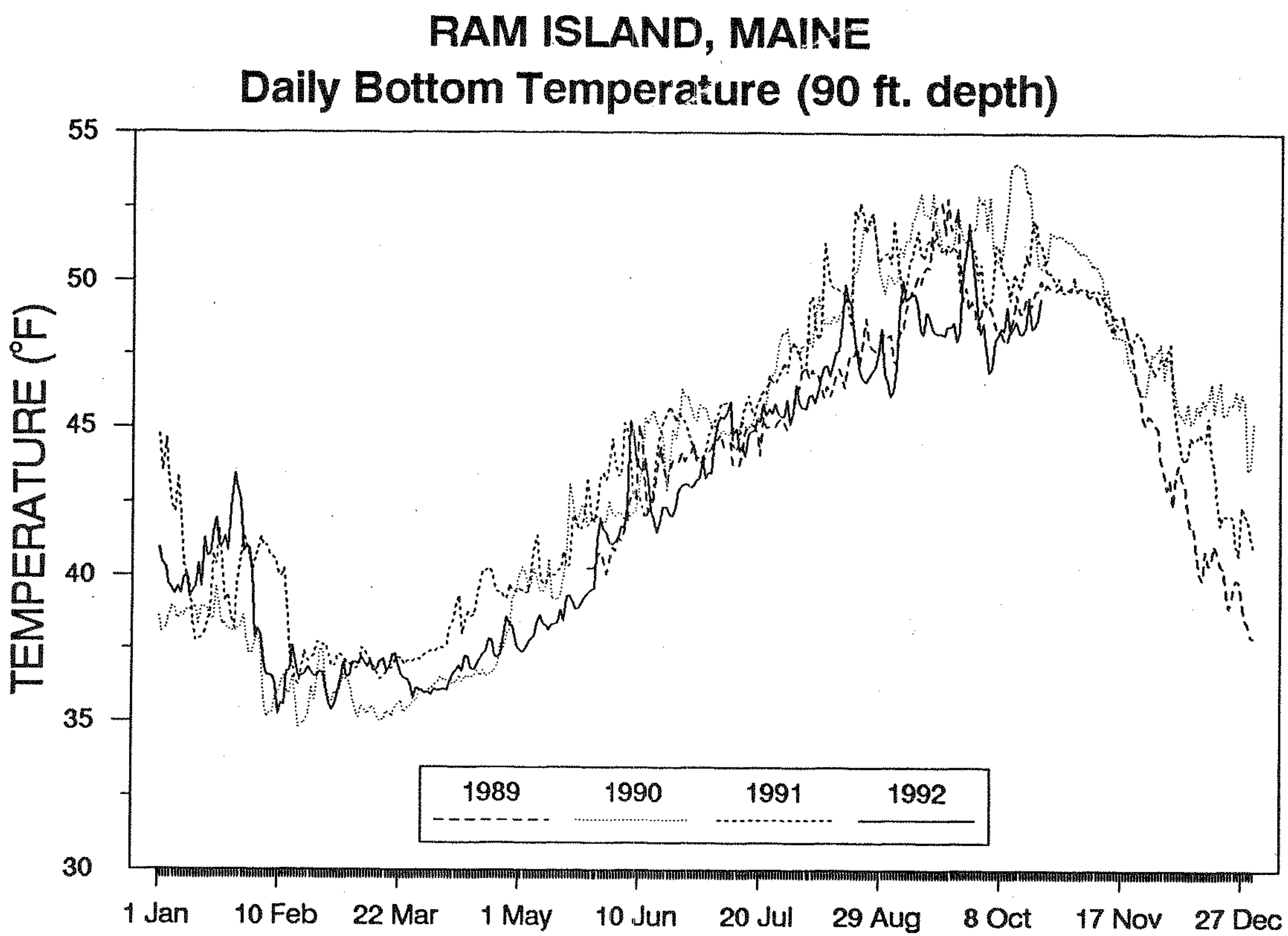

Figure 2. Mean daily bottom temperature at Ram Island, Maine during 1989-92.

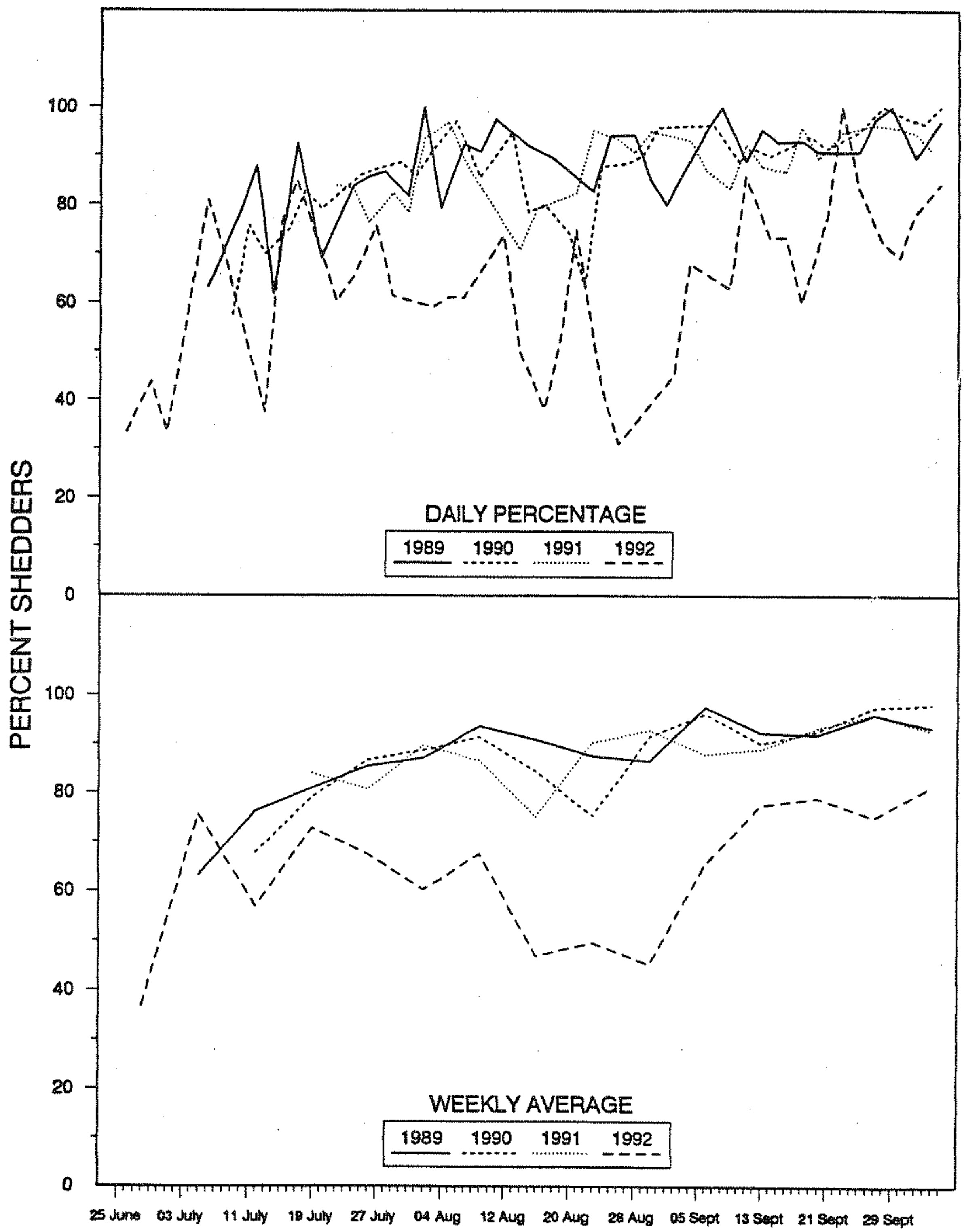

Figure 3. Percentage of shedders in legal-size catch from DMR research trap catches near Boothbay Harbor, 1989-92.